Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

Mining Research Laboratories
Laboratoires de recherche minière

1990 CONFERENCE ON STRESSES IN UNDERGROUND STRUCTURES

G. Herget

MRL 91-014 (TR) January 1991

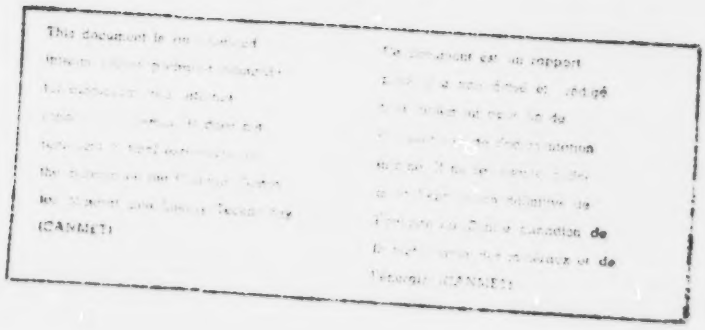
Canada

92-01192/

1990 CONFERENCE ON STRESSES IN UNDERGROUND STRUCTURES

G. Herget

MRL 91-014 (TR) January 1991



29 pp

MICROMEDIA

1990 CONFERENCES ON STRESSES IN UNDERGROUND STRUCTURES

G. Herget*

ABSTRACT

This report provides budget information, attendance figures and an appendix with copies of printed information for the organization of the conference on Stress in Underground Structures, October 2-4, 1990, Ottawa.

---

* Research Scientist, Canadian Mine Technology Laboratory, Mining Research Laboratories, CANMET, Energy, Mines and Resources, Ottawa, Ontario

KEYWORDS: Budget, Conference, Stresses.

CONFÉRENCES SUR LES CONTRAINTES DANS LES STRUCTURES SOUTERRAINES, ORGANISÉES EN 1990

G. Herget*

RÉSUMÉ

Le présent rapport contient de l'information sur les crédits budgétaires, des données sur les présences et une annexe incluant des exemplaires de la documentation concernant l'organisation de la Conférence sur les contraintes dans les structures souterraines qui a eu lieu à Ottawa, du 2 au 4 octobre 1991.

* Chercheur scientifique , Laboratoire canadien de technologie minière, Laboratoires de recherche minière, CANMET, Énergie, Mines et Ressources, Ottawa (Ontario).

Mots clés : prévisions budgétaires; conférence; contraintes.

TABLES OF CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	ii
INTRODUCTION	1
ORGANIZATION	1
BUDGET	2
Appendix 1	

TABLES

Table 1	Final Budget	3

INTRODUCTION

In the fall of 1989 it was decided at the Mining Research Laboratories that a speciality conference on Stresses in Underground Structures should be organized for the Fall of 1990. This conference was to combine the topics:

1. Ground Stress Determinations
2. Prediction of Stresses for Underground Openings
3. Monitoring of Stress Redistribution

In addition a small instrumentation show and a workshop on 3D-numerical modelling was to be prepared.

In the following organizational details and budget information are provided.

ORGANIZATION

The responsibility for organizing the conference was distributed as follows:

Dr. G. Herget, Conference Chairman
Mr. Y. Yu, Conference Co-Chairman
Mr. M. Gyenge, Exhibits and Posters
Dr. T. Aston, Translation
Dr. S. Vongpaisal, Finance
Mr. D. Labrie, Audio-visual
Mr. D. Walsh, Hospitality
Mr. Y. Yu, Numerical Modelling Workshop

Session chairmen:

Session 1. Dr. B. Arjang
Session 2. Mr. Y. Yu
Session 3. Dr. G. Herget

The Venture Inn in Ottawa was selected as venue and the date was set to Oct. 2-3, 1990. Ten Journals with geotechnical coverage were approached immediately to have the conference date appear in their regularly published calendar of events. An announcement was then mailed to each potential delegate on the MRL mailing list.

This was then followed up by an additional mailing containing the registration form by Venture Inn about three months before the conference.

The Venture Inn agreed to accept registration fees together with advance payments for accommodation. They refused however to handle the payment of expenses except the refund of registration fees prior to the conference.

BUDGET

A budget was set up as an early stage and updated as required. the final budget is presented in Table 1. The first budget formed the basis for the memorandum to the Minister (Sept. 19, 1990) requesting approval for an expenditure up to $33000 to sponsor a conference.

The conference was very well received and a total of 18 participants registered for the numerical modelling workshop. 80 delegates registered for the conference of which 63 paid registration fees while organizers and helpers were given free access without having to pay the registration fee. The conference

budget shows a small profit of $2732.60 based on estimated future sales of proceedings through Bitech Publishers Ltd., Vancouver. The appendix presents additional information and publications which might be useful at a later date.

Table 1. Final budget

	Receipts($)	Expenses($)
Receipts		
Registration fees (Conference, exhibits, workshop)	20592.50	
Sale of proceedings	110.00	
Future sale of proceedings by Bitech Publishers, Vancouver, B.C.	4550.00	
Expenses		
Room rental		1103.00
Postage, credit and bank charges		610.75
Numerical modelling equipment rental		1281.24
Audio-visual and translation equipment rental		3741.00
Hospitality delegate kits, meals, dinner speaker		11107.11
Advertising, signs, furniture rentals		2676.80
Cost of proceedings (estimate)		2000.00
Profit	25252.50	25252.50

APPENDIX 1

	Page
Announcement	A- 1
Registration form	A- 2
Invitation of delegates	A- 4
Preliminary program	A- 6
Final program	A-11
Instructions for preparing manuscripts	A-14
Invitation to exhibit	A-17
Information for exhibitors	A-18
Booth registration form	A-20
Post conference workshop	A-21
Cover of proceedings	A-23

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

ANNOUNCEMENT

Please note in your calendar the following SPECIALITY CONFERENCE:

STRESSES IN UNDERGROUND STRUCTURES: DETERMINATION, PREDICTION AND MONITORING

Time and location: October 2-3, 1990 - Venture Inn, Ottawa, Ontario, Canada

Sponsor: Mining Research Laboratories, Canada Centre for Mineral and Energy Technology (CANMET, EMR)

Conference Chairman: Dr. G. Herget
Conference Co-chairman: Y. Yu

Simultaneous translations into French and English will be provided and a poster session will be organized. At the poster session there will be space for a limited number of equipment exhibits.

Estimated size of event: 150 participants

Registration fee: $240 (including two lunches and one dinner)

Conference hotel: $66/night with reservation by September 6, 1990

Please let us know whether you are interested to participate. In case you are prepared to submit a paper, please send in a 200 to 300 word abstract by April 2, 1990.

AVIS

Veuillez ajouter à votre calendrier la CONFÉRENCE SPÉCIALISÉE suivante:

CONTRAINTES DES STRUCTURES SOUTERRAINES: DÉTERMINATION, PRÉDICTION ET SURVEILLANCE

Date et endroit: les 2 et 3 octobre 1990 -Venture Inn, Ottawa, Ontario, Canada

Commanditaire: les Laboratoires de recherche minière du Centre canadien de la technologie des minéraux et de l'énergie (CANMET, EMR)

Président: Dr. G. Herget
Co-président: Y. Yu

La traduction simultanée en anglais ou en français sera offerte et une session d'affichage sera organisée. À la session d'affichage, il y aura de l'espace pour montrer un nombre limité de pièces d'équipements.

Nombre de participants envisagés: 150

Frais d'inscription: $240 (incluent 2 dîners et 1 souper)

Hotel: $66/nuit avec réservation avant le 6 septembre 1990.

Laissez-nous savoir si vous désirez contribuer. Dans le cas échéant, nous vous prions de nous faire parvenir un résumé d'article, de 200 à 300 mots avant le 2 avril, 1990.

Address inquiries to/Pour plus de renseignements:

Dr. G. Herget, Canadian Mine Technology Laboratory, MRL/CANMET
555 Booth Street (BCC 10), OTTAWA, Ontario, Canada, K1A 0G1
Tel: (613) 996-4027 Fax: (613) 995-3456

Canada

Registration Form
Formule d'inscription

Please complete and return this form with payment in the enclosed envelope. All communications regarding Congress registration should be addressed to:
Venture Inn, 480 Metcalfe St., Ottawa, Ont., K1S 3N1 c/o: CANMET Conference
Ce formulaire doit être complété et retourné avec paiement dans l'enveloppe ci-jointe. Toute correspondance reliée au congrès doit être adressée au:
Venture Inn, 480 Metcalfe St., Ottawa, Ont., K1S 3N1 a/s: Conférence CANMET

Surname / Nom : _____ **First Name / Prénom :** _____

Title / Titre : _____

Organisation : _____

Phone # / # de téléphone : _____ **Fax # / # de Fax :** _____

Postal Address / Adresse postale :

_____

_____

Prefered Language? / Langue préférée? ○ **English** ○ **Français**

Registration Fee / Frais d'inscription

The registration fee includes two lunches, one dinner and the proceedings. Additional tickets for meals may be purchased at registration time.
Deux déjeuners, un dîner et les comptes rendus sont inclus dans les frais d'inscription. Des billets additionnels pour les repas peuvent être achetés à l'inscription.

Please indicate / S'il vous plait indiqué :

Delegate / Délégé : $240.00 ○ **Student / Étudiant: $75.00** ○

Those paying the special student rate must attach a letter from the head of their department confirming that they are full-time students and not in paid employment.
Les demandes d'inscription des étudiants doivent être accompagnées d'une lettre du directeur du département de l'institution d'enseignement impliquée stipulant le status d'étudiant à plein temps sans emploi rémunéré.

3D-BEAP Workshop / 3D-BEAP Atelier
Registration Fee / Frais d'Inscription $250.00 ○

(Oct. 4, Bells Corners Complex, details see enclosed notice)
(Le 4 oct. Complexe Bells Corners, pour les détails voire l'information ci-jointe)

Accommodation / Logement

Venture Inn
480 Metcalfe St.,
Ottawa, Ontario
K1S 3N1
Canada

Telephone / Téléphone : (613) 237-8500
Fax : (613) 237-6705
Single/Double room : $69.30 per night (including taxes)
Chambre simple/double : $69.30 par nuit (incluent les taxes)

Are you making your own, separate arrangements for accommodation?
Désirez-vous faire vos propre réservations d'hôtel? ◯ YES/OUI ◯ NO/NON

If you wish to reserve accommodation at the Venture Inn, please provide your arrival and departure dates below. Reservations are not held after 6:00 p.m. unless guaranteed by credit card or deposit.
Si vous désirez réserver votre logement au Venture Inn, prière d'indiquer la date d'arrivée et de départ ci-dessous. Un dépôt par chèque ou carte de crédit est requis pour garantir les réservations après 6:00 p.m.

Arrival date: _____ Time: _____ p.m./a.m.
Date d'arrivée: _____ à: _____ h

Departure date: _____ Time: _____ p.m./a.m.
Date de départ: _____ à: _____ h

single/simple ◯ double ◯ king/grand lit ◯ triple ◯ quadruple ◯

Sharing with / Partagé avec: _____ Check out time / Heure de départ 1:00 p.m.

Payment / Paiement

Make payments by cheque, money order, bank draft or credit card in Canadian dollars, payable to: Venture Inn (CANMET STRESS). Please note that cancellations received after August 1, 1990 will be subject to a cancellation fee of 25%.
Faire le paiement en dollars canadien par chèque, carte de crédit ou billet bancaire à Venture Inn (CANMET STRESS). Les annulations reçues après le 1er, août 1990 seront sujettes à des frais d'annulation de 25%.

Registration / Inscription : $ _____

Accommodation / Logement : $ _____

Extra meal tickets
Billets en plus pour les repas
1 Dinner / 1 dîner $30.00 : $ _____

2 Lunches / 2 déjeuners $30.00 : $ _____

Workshop /Atelier $250.00 : $ _____

Total Payment / Paiement Total : $ _____

AMOUNT ENCLOSED / PAIEMENT : $ _____

Payment by credit card: / Paiement par carte de crédit:

Card # / # de carte: _____ Expiry date / Date d'expiration: _____

VISA ◯ MASTERCARD ◯ AMERICAN EXPRESS ◯

Signature: _____ Date: _____

Energy, Mines and Resources Canada
Energie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

Dear Delegate,

The preparations for the CANMET speciality conference on:

STRESS DISTRIBUTIONS IN UNDERGROUND STRUCTURES

are well advanced and attached you find the program according to received contributions. We hope you will have the time to attend. Please use the attached registration form. All funds are to be sent to the Venture Inn with the label "CANMET STRESS". The number of participants is limited to 110.

The Venture Inn, where the conference is to be held, has a block of rooms reserved for delegates. However, the hotel will honor this commitment only if reservations are received by September 6, 1990. After this date the block of rooms will be released to the public. Hotel accommodation in Ottawa is scarce in the Fall and some of the remaining choices might be expensive.

On October 4, 1990 a full day optional workshop will be organized on a 3d - boundary element applications package. The workshop will be held at the Mining Research Laboratories, Bells Corners Complex, Nepean, Ontario if numbers warrant. The cost is $250.

We hope to meet you for an interesting two days of presentations and discussions in Ottawa.

Yours sincerely,

Dr. G. Herget, Chairman (613)996-4027
Mr. Y. Yu, Co-Chairman (613)996-1809
Mr. M. Bétournay, Translations (613)995-1147
Dr. S. Vongpaisal, Finance and Printing (613)996-4302
Mr. M. Gyenge, Exhibits (613)996-4006

Fax (613)995-3456

Canada

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

Cher délégué,

Les préparations pour la conférence spécialisée CANMET sur la:

DISTRIBUTION DES CONTRAINTES DANS LES STRUCTURES SOUTERRAINES

vont bon train et vous pouvez trouver ci-joint le programme basé sur les propositions reçues. Nous espérons que vous trouverez le temps pour assister à cette conférence. Tous les paiements doivent être acheminés au Venture Inn avec l'inscription "CANMET STRESS". Le nombre de participants est limité à 110.

Le Venture Inn, où se tiendra la conférence, a réservé un groupe de chambres à l'intention des délégués. Cependant, cet engagement ne vaut seulement que pour les réservations qui seront parvenues avant le 6 septembre 1990. Après cette date, les chambres restantes seront offertes au public en général. L'hébergement à Ottawa l'automne est rare, et les chambres alors disponibles pourraient s'avérer dispendieuses.

L'organisation d'un atelier d'une journée, sur les applications d'un logiciel d'éléments-frontière 3-D, a été planifiée pour le 4 octobre 1990. L'atelier se tiendra aux laboratoires de recherche minière, complexe de Bells Corners, Nepean (Ottawa), Ontario, si le nombre le permet. Les frais d'inscription ont été fixés à $250.

Nous espérons vous rencontrer à Ottawa pour ces intéressantes journées de présentation et de discussion.

Sincèrement vôtre,

Richard Herget

Dr. G. Herget, Président (613) 996-4027
Mr. Y. Yu, Co-président (613) 996-1809
Mr. M. Bétournay, Traduction (613) 995-1147
Dr. S. Vongpaisal, Finance et Impression (613) 996-4302
Mr. M. Gyenge, Exposition (613) 996-4006

Fax (613) 995-3456

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

PRELIMINARY PROGRAM

CANMENT SPECIALITY CONFERENCE ON STRESSES IN UNDERGROUND STRUCTURES

October 2, 1990

08:30 Introduction of Head Table - Dr. G. Herget, Conference Chairman
Welcome Remarks - Dr. J. Udd, Director, MRL, CANMET
Mining Research Objectives - Mr. J. Gordon, V.P., Noranda Inc.
Government Partnerships in Mining Research
- Dr. M.D. Everell, Assistant-Deputy Minister, EMR

09:40 Coffee

10:00 Session I - **Ground Stress Determinations** - Session Chairman: B. Arjang

Do the Rocks Remember? Regional Stress Provinces in Canada their Interpretation and Cause - J.S. Bell and J. Adams
Stresses in the Canadian Shield - G. Herget and B. Arjang
The Modified Doorstopper Cell Stress Measuring Technique - D.E. Gill and R.Corthesy
In Situ Stress Determination by Stress Change Monitoring - P.K. Kaiser
A New Approach for the Statistical Treatment of Stress Tensors - T.D. Wiles and P. Kaiser

12:10 Lunch

13:15 Stress Domains at the Underground Research Laboratory of AECL - C.D. Martin
In Situ Stress Measurements in Three of Noranda's Mines using a Novel Borehole Slotting Method - H. Kanduth and P. Germain

Session II - **Prediction of Stresses for Underground Openings**

- Session Chairman: Y. Yu
A Mine Structural Evaluation Procedure Based on Field Stress Determinations, Rock Classification and Numerical Modelling - J.F. Archibald, E.M. De Souza, P. Lausch and C.W. Pelly
A Block-Spring Method for Stability Analyses of Excavations in Jointed Rocks - B. Wang and V.K. Garga

15:00 Coffee

15:15 An Effective Stress/Strength Approach to the Simulation of Gas Induced Outbursts - K. Barron and D. Kullmann
Stress Analysis of Rock Mass with Cable Support: A Finite Element Approach - H.S. Mitri and H. Rajaie

16:05 Poster Session and Equipment Exhibit

19:00 Dinner and Key Note Address

Canada

CANMET SPECIALITY CONFERENCE ON STRESSES IN UNDERGROUND STRUCTURES

October 3, 1990

08:35 Session II Continued

3d-Boundary Element Method for Calculating the Stresses of Underground Mine Openings - Ithaska
Geomechanical Assessment of a Large Open Stope at Depth - T.R. Yu, J.G. Henning and D.B. Counter
Influence of Rock Mass Constitutive Model on Predicted Stress Distributions in Mining - J.H. Curran and M. Grabinsky
Boundary Element Applications Package for 3d-Stress Analysis of Mining Structures - Y. Yu, L. Closset, J.A.C. Diering

09:50 Coffee

Session III - **Monitoring of Stress Redistribution in Underground Structures** - Session Chairman: G. Herget

Stress Monitoring at Depth in Creighton Mine - D. Landriault and J. Galbraith
Monitoring Equipment for the Determination of Stress Redistribution - G. Herget
Consolidation Monitoring in Salt Tailings Backfill - B.V. Roulston, R.J. Beddoes and J.J. Streisel
Use of In Situ and Laboratory Testing for Calibration of a Numerical Model for a Potash Mine - M.A. Frayne and D.Z. Mraz

11:55 Lunch - Poster Sessions and Equipment Exhibits

13:30 Location of High Stress Zones in Sill Pillars by Geotomography - P. Young
Back Analysis of Surface Crown Pillar Stresses - C. Yuen and T. Carter

14:00 Technology Transfer on Mining with Salt Backfill at Denison-Potacan: Numerical Modelling, Placement, Testing and Monitoring - S. Munroe, D. Mraz, C. Monahan, L. Rothenburg

16:00 Closing Remarks: Dr. J. Udd, Director, MRL

16:15 Adjourn

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

PROGRAMME PRÉLIMINAIRE

CONFÉRENCE SPÉCIALISÉE CANMET SUR
LES CONTRAINTES DANS LES STRUCTURES SOUTERRAINES

2 octobre 1990

08:30 Introduction de la table d'honneur - Dr. G. Herget, Président de la conférence
Remarques de bienvenue - Dr. J. Udd, Directeur, LRM, CANMET
Objectifs de la recherche minière - Mr. J. Gordon, Vice-président, Noranda inc.
Partenariats gouvernementaux en recherche minière - Dr. M.D. Everell, Sous-ministre adjoint, EMR Canada

09:40 Pause café

10:00 Session I - **Détermination des contraintes naturelles** - Président de session: B. Arjang

Est-ce que les roches se souviennent? Régions de contraintes au Canada, leur interprétation et leur cause - J.S. Bell et J. Adams
Contraintes dans le Bouclier Canadien - G. Herget et B. Arjang
La technique de mesure des contraintes à l'aide de la cellule 'Doorstoper' modifiée - D.E. Gill et R. Corthésy
Détermination des contraintes in-situ par suivi des variations de contrainte - P.K. Kaiser
Une nouvelle approche pour le traitement statistique des tenseurs de contrainte - T.D. Wiles et P. Kaiser

12:10 Pause déjeuner

13:15 Domaines de contrainte au Laboratoire de recherche souterraine du LEAC - C.D. Martin
Mesure des contraintes in-situ dans trois mines du groupe Noranda à l'aide de la nouvelle méthode de rainure de forage - H. Kanduth et P. Germain

Session II - **Prediction des contraintes autour des ouvertures souterraines** - Président de session Y. Yu

Une procédure d'évaluation structurale basée sur la détermination des contraintes en place, la classification du rocher et la modélisation numérique - J.F. Archibald, E.M. De Souza, P. Lausch et C.W. Pelly
Un modèle bloc-ressort pour l'analyse de stabilité des excavations dans les rochers joints - B. Wang et V.K. Garga

15:00 Pause café

15:15 Une approche effective contrainte/résistance pour la simulation des éclatements du roc causés par des poches de gaz - K. Barron et D. Kullman
Analyse de contrainte des massifs rocheux renforcés par câbles: une approche par élément finis - H.S. Mitri et H. Rajaie

Canada

CONFÉRENCE SPÉCIALISÉE CANMET SUR
LES CONTRAINTES DANS LES STRUCTURES SOUTERRAINES

16:05 Session d'affiches et exposition d'équipement

19:00 Diner et conférence principale

3 octobre 1990

08:35 Session II (suite)

Modèle d'éléments finis 3-D pour les opérations minières de Sudbury - Itaska
Évaluation géomécanique d'un grand chantier ouvert et profond - T.R. Yu, J.G. Henning et D.B. Counter
Influence du modèle constitutif du massif rocheux sur la prévision des distributions de contrainte dans le milieu minier - J.H. Curran et M. Grabinsky

09:50 Pause café

10:00 **Session III - Suivi des redistributions de contraintes dans les structures souterraines** - Président de session: G. Herget

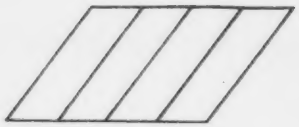
Suivi des contraintes en profondeur à la Mine Creighton - D. Landriault et J. Galbraith
Équipement de suivi pour la détermination de la redistribution des contraintes - G. Herget
Suivi de la consolidation du remblai composé de résidus de sel - B.V. Roulsten, R.J. Beddoes et J.J. Streisel
Utilisation d'essais en laboratoire et en place pour la calibration d'un modèle numérique pour une mine de potasse - M.A. Fayne et D.Z. Mraz

11:55 Déjeuner - Session d'affiches et exposition d'équipements

13:30 Localisation de zones de contrainte élevée dans les piliers de sole par géotomographie - P. Young
Retroanalyse des contraintes dans les piliers de surface - C. Yuen et T. Carter
Transfert technologique sur le minage avec remblai salin à la mine Denison - Potocan: Modélisation numérique, mise-en-place, essai et suivi - S. Munroe, D. Mraz et C. Monahan

16:00 Remarques de clôture - J. Udd, Directeur, LRM

16:15 Fin de la conférence



CANMET

Notes

Organizing Committee:

Dr. G. Herget, Conference Chairman
Mr. Y. Yu, Conference Co-Chairman
Mr. M. Gyenge, Exibits and Posters
Dr. T. Aston, Translation
Mr. D. Labrie, Audio-visual Equipment
Dr. S. Vongpaisal, Finance
Mr. D. Walsh, Hospitality

PROGRAM

Stresses in Underground Structures

For futher information, please contact

S. Vongpaisal
555, Booth Street
Ottawa, Ontario
(613) 996-4302

G. Herget
555, Booth Street
Ottawa, Ontario
(613) 996-4027

Venture Inn, Ottawa
Oct. 2 - 3, 1990

CANMET Speciality Conference, Oct. 2-3, 1990 Venture Inn, Ottawa

STRESSES IN UNDERGROUND STRUCTURES

October 2, 1990 - Rideau Room

8:30 Introduction of Head Table
Dr. G. Herget,
Conference Chairman

8:35 Mining Research Objectives
Mr. J. Gordon, V.P.
Noranda Inc.

8:55 Government Partnerships in Mining Research
Dr. M.D. Everell
Assistant Deputy Minister, EMR

GROUND STRESS DETERMINATIONS

10:05 Coffee - Gallery

Session I: B. Arjang, Chairman

9:15 Do the Rocks Remember? How Contemporary are Regional Stresses in Canada?
J. S. Bell and J. Adams

9:40 Mapping Regional Stress Provinces in Canada - A Progress Report
J. Adams and J.S. Bell

10:25 Update on Ground Stresses in the Canadian Shield
G. Herget and B. Arjang

10:50 The Modified Doorstopper Cell Stress Measuring Technique
R. Corthesy, D.E. Gill, D. Nguyen

11:15 In Situ Stress Determination For Mine Design by Stress Change Monitoring
P.K. Kaiser

11:40 A New Approach for the Statistical Treatment of Stress Tensors
T.D. Wiles and P. Kaiser

12:05 Buffet Lunch - Gallery

13:15 Quality Control of Overcoring Stress Measurements
P.M. Thompson

13:40 Stress Domains at the Underground Research Laboratory of AECL
C.D. Martin

14:05 In Situ Stress Measurements in Three of Noranda's Mines using a Novel Borehole Slotting Method
H. Kanduth and P. Germain

PREDICTION OF STRESSES FOR UNDERGROUND OPENINGS

14:30 Session II: Y. Yu, Chairman

14:30 A Block-Spring Method for Stability Analyses of Excavations in Jointed Rocks
B. Wang and V. K. Garga

14:55 Coffee - Gallery

15:15 An Effective Stress/Strength Approach to the Simulation of Gas Induced Outbursts
K. Barron and D. Kullmann

15:40 Stress Analysis of Rock Mass with Cable Support: A Finite Element Approach
H. S. Mitri and H. Rajaie

16:05 Penthouse Poster Session and Equipment Exhibits

19:00 Dinner and Address
Speaker: Dr. J. Franklin,
President ISRM

October 3, 1990 - Rideau Room

8:30 Session II Continued

8:30 3d-Boundary Element Method for Calculating the Stresses of Underground Mine Openings
M. G. Mack, D. M. Morrison, Y. S. Yu

8:55 Geomechanical Assessment of a Large Open Stope at Depth
T. R. Yu, J. G. Henning,
D. B. Counter

9:20 Numerical Stress Analysis in Mining Pragmatic Approaches to pratical Solutions
M. Grabinsky and J. H. Curran

9:45 BEAP 3D - Applications Package for 3d-Stress Analysis of Mine Structures
Y. S. Yu, L. Closset, J. A. Diering

10:10 Coffee - Gallery

MONITORING OF STRESS REDISTRIBUTION

Session III: G. Herget, Chairman

10:30 Stress Monitoring at Depth in Creighton Mine
D. Landriault, J. Galbraith, K. Zeitz

10:55 Monitoring Equipment for the Determination of Stress Redistribution
G. Herget

11:20 Consolidation Monitoring in Salt Tailings Backfill
B. V. Roulston, R. J. Beddoes, G. Herget

11:45 Use of In Situ and Laboratory Testing for Calibration of a Numerical Model for a Potash Mine
M. A. Frayne and D. Z. Mraz

12:10 Buffet Lunch - Gallery

13:20 Location of High Stress Zones in Sill Pillars by Geotomography
P. Young

13:45 Back Analysis of Surface Crown Pillar Stresses
T. G. Carter, C. M. K. Yuen,
J. S. U. Wong, S.V. L. Barret

TECHNOLOGY TRANSFER

14:10 Technology Transfer on: Mining with Salt Backfill at Denison-Potacan: Numerical Modelling, Placement, Testing and Monitoring
C. Monahan, D. Mraz, S. Munroe,
L. Rothenburg

15:10 Coffee - Gallery

16:30 Closing Remarks - Adjourn

Conférence spécialisée CANMET, les 2 et 3 octobre 1990, Venture Inn, Ottawa

LES CONTRAINTES DANS LES STRUCTURES SOUTERRAINES

PROGRAMME

Le 2 octobre 1990, salle Rideau

8h30 Introduction de la table d'honneur
Dr. G. Herget, président de la conférence

8h35 Objectifs de la recherche minière
M. J. Gordon, vice-président, Noranda inc.

8h55 Partenariats gouvernementaux en recherche minière
Dr. M.D. Everell, sous-ministre adjoint, EMR Canada

DÉTERMINATION DES CONTRAINTES NATURELLES

Session I M. B. Arjang, président

9h15 Les roches se souviennent-elles? Régions de contraintes au Canada, leur interprétation et leur cause
MM. J.S. Bell et J.Adams

9h40 Compilation des régions de contrainte au Canada, un rapport d'avancement
MM. J. Adams et J.S. Bell

10h05 Pause café - Galerie

10h25 Mise à jour des contraintes dans le Bouclier canadien
MM. G. Herget et B. Arjang

10h50 La technique modifiée de mesure des contraintes à l'aide de la cellule 'Doorstoper'
MM. D.E. Gill, R. Corthésy et D. Nguyen

11h15 Détermination des contraintes in situ par le suivi des variations de contrainte
M. P.K. Kaiser

11h40 Une nouvelle approche pour le traitement statistique des tenseurs de contrainte
MM. T.D. Wiles et P. Kaiser

12h05 Déjeuner - Galerie

13h15 Contrôle de la qualité des contraintes mesurées par surcarottage
M. P.M. Thompson

13h40 Domaines de contrainte au Laboratoire de recherche souterraine des LEAC
M. C.D. Martin

14h05 Mesure des contraintes in situ dans trois mines du groupe Noranda à l'aide de la nouvelle méthode de rainure de forage
MM. H. Kanduth et P. Germain

PRÉDICTION DES CONTRAINTES AUTOUR DES OUVERTURES SOUTERRAINES

Session II M. Y. Yu, Président

14h30 **Un modèle bloc-ressort pour l'analyse de stabilité des excavations dans les rochers joints**
MM. B. Wang et V.K. Garga

14h55 **Pause café - Galerie**

15h15 **Une approche contrainte/résistance effective pour la simulation des éclatements du roc causés par des poches de gaz**
MM. K. Barron
et D. Kullmann

15h40 **Analyse de contrainte des massifs rocheux renforcés par câbles: une approche par élément finis**
MM. H.S. Mitri
et H. Rajaie

16h05 **Session d'affiches et exposition d'équipement Penthouse - Salles est et ouest**

19h00 **Dîner et conférence principale**
Conférencier:
M. J. Franklin, président SIMR

Le 3 octobre 1990, salle Rideau

Session II (suite)

8h30 **Modèle d'éléments frontière 3D pour le calcul des contraintes autour des ouvertures souterraines**
MM. M.G. Mack,
D.M. Morrison et Y.S. Yu

8h55 **Évaluation géomécanique d'un grand chantier ouvert profond**
MM. T.R. Yu, J.G.Henning
et D.B. Counter

9h20 **Approches et solutions pratiques pour l'analyse numérique des contraintes en milieu miner**
MM. M. Grabinsky et
J.H. Curran

9h45 **BEAP 3D - Programme d'applications pour l'analyse 3D des contraintes dans les structures minières**
MM. Y.S. Yu, L. Closset
et J.A. Diering

10h10 **Pause café - Galerie**

SUIVI DE LA REDISTRIBUTION DES CONTRAINTES

Session III: G. Herget, président

10h30 **Suivi des contraintes en profondeur à la mine Creighton**
MM. D. Landriault,
J. Galbraith et K. Zeitz

10h55 **Équipement de suivi pour la mesure des redistributions de contrainte**
M. G. Herget

11h20 **Suivi de la consolidation dans des remblais composés de résidus salins**
MM. B.V. Roulsten,
R.J. Beddoes et
J.J. Streisel

11h45 **Utilisation d'essais en laboratoire et en place pour la calibration d'un modèle numérique pour une mine de potasse**
MM. M.A. Frayne
et D.Z.Mraz

12h10 **Déjeuner - Galerie**

13h20 **Localisation des zones de contrainte élevée dans les piliers de sole par géotomographie**
M. P. Young

13h45 **Rétroanalyse des contraintes dans les piliers de surface**
MM. T.G. Carter,
C.M.K. Yuen,
J.S.U. Wong et
S.V.L. Barrett

TRANSFERT DE TECHNOLOGIE

14h10 **Minage avec remblai salin à la mine Denison-Potacan: Modélisation numérique, mise-en-place, essai et suivi**
MM. C. Monahan, D. Mràz,
S. Munroe et
L. Rothenburg

15h10 **Pause café - Galerie**

15h20 **Transfert de technologie continue**

16h15 **Remarques de clôture**

16h30 **Fin de la conférence**

INSTRUCTIONS FOR PREPARING MANUSCRIPTS

The proceedings for the Conference on Stresses in Underground Structures will be prepared from camera-ready copy submitted by the authors. Manuscripts must be prepared on the paper supplied and in conformance with the following requirements. Please ask if more sheets are required. A sample publication is included. The manuscript will be photographed and reproduced in the size submitted.

1. Type on one side only of the special manuscript paper provided. All copies must be typewritten clearly and accurately using fresh black ribbon so that copy will reproduce well. Type single space, over the full page, using a Prestige Elite 12 type face.

2. The length of the paper should be a maximum of 10 pages, including diagrams and tables.

3. Light blue guide lines have been printed on each sheet outlining the typing area of the full page. **DO NOT TYPE BEYOND THESE LINES.**

4. The entire text must be typed justified left, no indents used for paragraphs. The text must be typed justified right, finishing at the right border line.

5. Leave single line spacing between paragraphs and double line spacing before a new heading

6. The title should appear across the top of the first page, beginning at the left blue margin, on line 4. The author's name should be below the title with initials in capitals starting at the left blue margin, on line 7. The affiliation will go on the next line. Authors with the same affiliation should have their names on the same line, affiliation on the next line. In the case of more than one affiliation list author's name(s) and affiliation below previous authors, separated by an empty line. Only use initials of given names and full family name. Please do not include the author's position title.

7. If the paper is in English the English abstract will start on line 19 with the title "ABSTRACT" in capitals letters beginning at the left blue margin. The text of the abstract will start on line 21 and will finish no lower than line 32. The French "RÉSUMÉ" will be arranged, in a similar fashion: RÉSUMÉ" title on line 35, abstract to start on line 37 and finish no lower than line 48. If the paper is in French, the French "RÉSUMÉ" will occupy lines 19 to 32, the English "ABSTRACT" will occupy lines 35 to 48.

   The authors will provide at least the English (French) abstract and can provide the French (English) abstract only if it is

legible and grammatically adequate. If a French (English) résumé is not provided the editor will translate the English (French) abstract into French (English).

8. Major headings should be in upper case, typed flush with left-hand margin, without underlining and on a separate line.

9. Sub-headings must be on a separate line and not underlined. Only the first of letter of every word (except articles and prepositions) capitalized, the other letters in lower case. The sub-headings will be typed flush with the left hand margin.

10. All references should be numbered and listed alphabetically by author's name at the end of the paper. The following should be provided for each reference: author's name and initials; title of article, abbreviated title of publication (underlined if a technical journal or a Proceeding); volume number; month or issue number; page numbers; year of publication. When referring to them in the text, type the author's name(s) and the year of publication in parenthesis.

11. Mathematics should be typed if possible. If handwritten this should be done clearly in black ink to ensure legibility.

12. Equations should be numbered in parenthesis flush with the right-hand margin. The equation should be centered between the left and right margins.

13. All symbols and abbreviations used must be clearly defined.

14. Authors are requested to use the International System, of Units (S.I.).

15. All illustrations, tables and line drawings must be clear black and white originals affixed with rubber cement within the body of the manuscript. They may be placed in the text or on separate pages as long as the following rules are respected.

- The total length of the manuscript is 10 pages.
- The tables and illustrations do not extend beyond the outside blue line.
- If illustrations are placed in the text two lines must separate the text from the table/illustation.
- No table or illustration is to be placed on the first page.

16. Photographs must be prepared on 1/2 tone 150 line screen and affixed with rubber cement in their required position within the lines of the manuscript.

17. All illustrations, photographs, tables, drawing must be correctly titled. Use Prestige Elite 12 pitch type without underlining. Do NOT use photostats, ozalids, blueprints, xerox, etc., for line drawings or photographs.

18. All manuscripts must be checked for acccuracy and completeness prior to submission. After receipt, it will not be possible to make revisions or corrections in the copy to be printed.

19. The manuscript should be free of smudges and erasures. If corrections are necessary, they should be made by painting out the errors with a white correcting fluid and then overtyping.

20. The page number of the paper and senior author's name should be marked lightly below the blue line at the bottom of each page using a non-reproducing blue pencil.

21. One original manuscript and one copy must be sent.

22. Do NOT fold or otherwise mutilate copies being sent through the mail. Place between cardboard covers.

23. Material will not be returned.

24. The manuscript must arrive at the address shown below by June 15, 1990.

25. The mailing address to return the camera-ready manuscript is:

    Dr. G. Herget
    CANMET, MRL
    555 Booth Street
    Ottawa, Ontario
    Canada
    K1A 0G1

26. The address for courier/rapid delivery of camera-ready manuscripts is:

    Dr. G. Herget
    CANMET, MRL
    Bells Corners Complex
    Robertson Road (old highway 7)
    3 km west of Bells Corners
    Bells Corners
    Nepean, Ontario
    Canada
    Tel: (613) 996-4027

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

INVITATION TO EXHIBIT

STRESSES IN UNDERGROUND STRUCTURES: DETERMINATION, PREDICTION AND MONITORING, a specialty Conference, will convene October 2-3, 1990 at the Venture Inn in Ottawa, Ontario. Organized by the Mining Research Laboratories, CANMET (Canada Centre for Mineral and Energy Technology), the Conference will bring together about 150 engineers and mining specialists, concerned with ground control, excavation, and excavation monitoring.

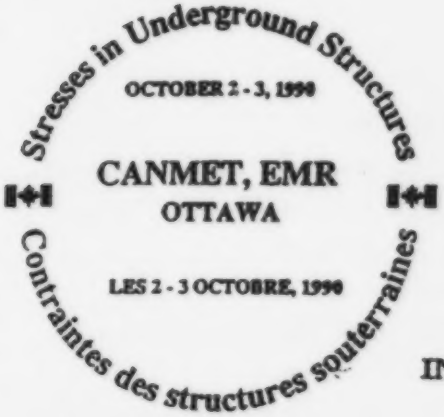
You are cordially invited to participate in the technical displays at the Penthouse of the Venture Inn. Technical poster displays are free of charge to registered delegates. In addition, five exhibit booths, suitable for light equipment, videos or instrumentation are available at a cost of $650, including one Conference registration.

To register your firm's exhibit at the STRESSES IN UNDERGROUND STRUCTURES Conference, please complete the attached form and return it with payment to M. Gyenge, Exhibition Manager, at the address below. Exhibit space will be allocated on a first pay basis, with the closing date, August 25, 1990. Please make cheque payable to: M. Gyenge (CANMET Stress).

Yours truly,

Dr. G. Herget, Conference Chairman
Canadian Mine Technology Laboratory,
MRL/CANMET
555 Booth Street (BCC 10)
Ottawa, Ontario, Canada
K1A 0G1
Tel: (613) 996-4027
Fax: (613) 995-3456

Canada



INFORMATION FOR EXHIBITORS

• LOCATION

Conference will be held at the Venture Inn in Ottawa, Ontario, October 2-3, 1990.

VENTURE INN
480 METCALFE STREET
OTTAWA, ONTARIO
K1S 3N1

• EXHIBIT SPACE

The five exhibition spaces are located in the East and West wings of the Penthouse, and are in the Poster Session area. Exhibit hours are 8:00 to 18:30, on October 2, 1990, and 8:00 to 15:00 on October 3, 1990.

• BOOTH SIZES AND RATES

The sizes of the exhibition booths are shown on the enclosed floor plan. Amenities include 6 ft. x 2.5 ft. tables, chairs, and power installations. Other specialized items, such as easels, wastebaskets, etc., are available for rent, but must be requested in advance.

Allocations of booths will be on a first pay basis, with rental fee of $650, including the cost of 1 Conference registration.

• SET-UP AND TAKE-DOWN

Set-up will take place October 1, from 18:00, with dismantling beginning at 15:30 on October 3rd, to be completed by 19:00. The docking area is located at the rear of the Venture Inn. Large trucks gain access off Pretoria Avenue.

• SECURITY

Exhibit areas will be locked during off-Conference hours between 18:30 and 8:00, with regular hotel surveillance in effect. Beyond the above, organizers cannot accept the responsibility for injury to persons, loss or damage to exhibits, or equipment by fire, accident, theft or other cause while at the Venture Inn.

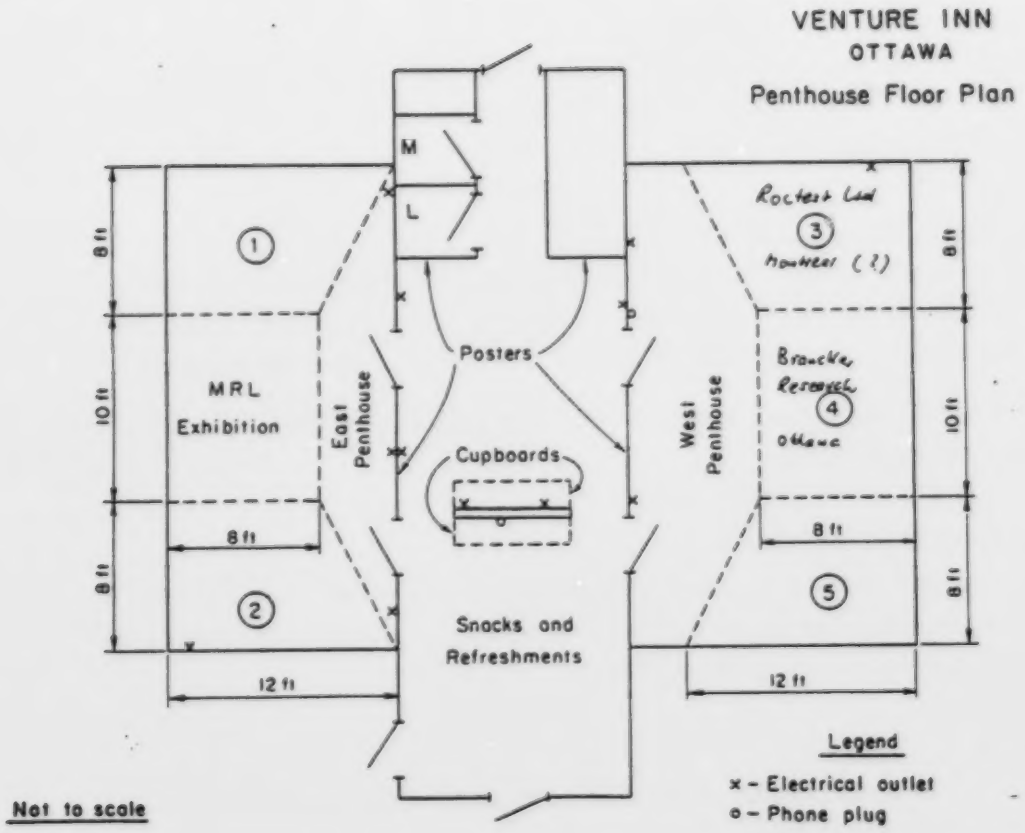
• SHIPMENTS ORIGINATING OUTSIDE CANADA

In case you need to select a Customs Broker, we suggest you call Tony Larivière at Mendelssohn Commercial Limited in Ottawa, telephone (613) 745-9737.

• BOOTH REGISTRATION

Reservation of exhibit area is accepted with payment in full only. **Please make cheque payable to M. Gyenge (CANMET Stress), and forward to:**

CANADIAN MINE TECHNOLOGY LABORATORY
MRL/CANMET
555 BOOTH STREET (BCC 10)
OTTAWA, ONTARIO, CANADA
K1A 0G1



BOOTH REGISTRATION FORM

- PLEASE RESERVE ONE BOOTH AT A COST OF $650 WHICH INCLUDES 1 CONFERENCE REGISTRATION ☐

  Our preference is for booth # _____
  Our second choice is booth # _____
  Our third choice is booth # _____

- EXHIBITOR'S NAME AND ADDRESS

  NAME:
  _____

  COMPANY:
  _____

  ADDRESS:
  _____

  TELEPHONE:
  _____

- Please state furniture required: chairs, tables, power outlets

  _____

- Please state special furniture required: wastebasket, screen, easels, etc.

  _____

- Amount Enclosed: Canadian $ _____
- Cheque payable to M. Gyenge (CANMET Stress)
- Conference Registrant for Name Badge:

  _____

CANADIAN MINE TECHNOLOGY LABORATORY
MRL/CANMET
555 BOOTH STREET (BCC 10)
OTTAWA, ONTARIO, CANADA
K1A 0G1
Telephone: (613) 996-4006
Fax: (613) 995-3456

Energy, Mines and Resources Canada | Énergie, Mines et Ressources Canada

CANMET

Canada Centre for Mineral and Energy Technology | Centre canadien de la technologie des minéraux et de l'énergie

One-Day Post Conference Workshop
3-D Boundary Element Application Package

October 4, 1990

Mining Research Laboratories

Bells Corners Complex, Bldg 10, Nepean, Ontario

An Overview

The BEAP software consists of: (a) a 3-D boundary element analysis program, and (b) an associated graphics processor.

The workshop will be organized following the Conference on Stresses in Underground Structures, if the number of participants is warranted. It provides an overview of some theoretical aspects, the capabilities and limitations of the 3-D BEAP software. An effort will be directed to provide hands-on experience for the participants.

BEAP performs three-dimensional stress analysis of underground excavations. Orthographic and perspective representation with rotations, hidden line removal, light source shading, stereoscopic vision of overall 3-D object, and fly-through animation have been incorporated with the graphic processor. This provides better display of mining structures, accuracy checking of input data, easy specification of stress/displacement calculation points, and presentation of analytical results graphically.

The graphics runs interactively on a Sun workstation under the Unix operating system. Ultimately, it will be transferred to a 386 under the Windows environment for the DOS operating system.

The BEAP package represents a state-of-the-art numerical modelling package for mining structures. The element type used provides numerous advantages for the stress modelling of mining excavations.

Application Areas

- Analysis of complex service excavations such as tunnel intersections and shaft layouts.
- Analysis of excavations created by massive mining operations, including open stoping, block caving, VBM, etc.
- Analysis of drawpoint layouts, and pillar design.
- Interaction of open pit and underground excavations.

Features of the Analysis Program

- It runs on Sun workstations under the UNIX operating system.
- Enables geometries with planar or curved surfaces to be modelled.
- Primitive stress loading or gravity loading.
- Modelling of different geological regions.
- Subregions may be infinite or finite.
- Stresses and displacements may be calculated at any point within the rock mass or at excavation surface.

Features of Graphics Processor Program

- Easy to use, menu-driven, and user friendly.
- Orthographic and perspective representation of mining structures.
- Real 3-D view is made possible by use of 3-D stereoscopic perspective using stereo-vision glasses.
- Accuracy checking of input data.
- Interior stress/displacement calculation points can be easily specified for a plane or section at any orientation in space, or for a 3-D block.
- Presentation of the analytical results graphically.
- Stress contours can be displayed either on a plane or section at any orientation in space, or for a full 3-D object.
- Stope/opening faces can be identified by different colors for easy identification.
- Currently, it is being developed under X-Windows environment on a Sun Workstation. Ultimately, it will be transferred to a 386 under the Windows environment for the DOS operating system.

Registration

Acceptance of registration will be on a first-come first-serve basis. Deadline for registration will be August 15, 1990.

The registration fee of $250.00 includes one lunch and lecture materials. A full refund will be made if a written cancellation is received on or before Sept. 15, 1990.

Address Inquiries to:

Y.S. Yu
Canadian Mine Technology Laboratory
MRL/CANMET
555 Booth Street (BCC 10), Ottawa, Ontario
K1A 0G1
Tel: (613) 996-1809 Fax: (613) 995-3456

Canada

ATELIER POST-CONFÉRENCE D'UNE JOURNÉE

Progiciel d'application d'éléments frontières (BEAP)
Le 4 octobre 1990
Laboratoires de recherche minière
Complexe Bells Corners, 10 Blvd. Nepean, Ontario

Vue générale

Le programme BEAP consiste en : (a) un programme d'analyse d'éléments frontières en trois dimensions et (b) un processeur graphique associé.

L'atelier sera organisé suite à la tenue de la Conférence sur les contraintes des structures souterraines, si le nombre de participants est suffisant. Il procurera une vue générale de quelques aspects théoriques, les capacités et les limites du progiciel BEAP. Un effort sera fait pour permettre aux participants de l'expérimenter par eux-mêmes.

Le BEAP réalise une analyse tridimensionnelle des contraintes des excavations souterraines. Il permet la représentation de projections axonométriques et en perspective incluant des rotations, la suppression des lignes cachées, la simulation des ombres dûes aux sources lumineuses et, représente une véritable vision en trois dimensions par l'utilisation d'une méthode stéréoscopique. Ceci permet une meilleure visualisation des structures minières et une amélioration du contrôle de la qualité des données, facilite la spécification des points de calculs des contraintes et déplacements et aide à la représentation graphique des résultats.

Le processeur graphique fonctionne de façon interactive à partir d'une station de travail Sun sous le système d'opération UNIX. Ultérieurement, il sera transféré à un modèle 386 avec un environnement Windows pour utilisation dans un système d'opération DOS.

Le BEAP est un système à la fine pointe de la technologie dans le domaine de la modélisation numérique des structures minières. L'élément type utilisé fournit de nombreux avantages pour la modélisation des excavations minières.

Zones d'application
- Analyse des excavations complexes de service tel les intersections de tunnels et tracés de puits
- Analyse des excavations créées par des opérations minières massives, incluant les exploitations à ciel ouvert, les exploitations par foudroyage, VBM, etc.
- Analyse des points de soutirage et de la conception des piliers
- Interaction entre une fosse et des excavations souterraines

Points saillants du programme d'analyse
- Il fonctionne sur une station de travail Sun sous un système d'opération UNIX
- Permet la simulation de surfaces planes et ou courbes
- Chargement par contraintes initiales ou par gravité
- Simulation de différentes régions géologiques
- Les sous-régions peuvent être finies ou infinies
- Les contraintes et les déplacements peuvent être calculés en tous points du massif rocheux ou des surfaces d'excavation

Points saillants du processeur graphique
- Facile à utiliser et est commandé par menu
- Représentation orthographique et en perspective des structures minières
- Une vue réelle en trois dimensions est rendue possible par l'emploi de la perspective tridimensionnelle stéréoscopique utilisant des lentilles à stéréovision
- Vérification exacte des données d'entrée
- Le calcul des points de contrainte et de déplacement peut être facilement spécifié pour un plan ou une section d'orientation quelconque, ou encore, pour un bloc tridimensionnel
- Présentation graphique des résultats de l'analyse
- Les contours de contraintes peuvent aussi être montrés sur un plan ou une section d'orientation quelconque, ou pour un bloc tridimensionnel
- Les faces des ouvertures et des chantiers peuvent être présentées par des couleurs différentes
- Le programme fonctionne sur une station de travail Sun utilisant un environnement X-Windows. Une version capable de fonctionner sur ordinateur personnel de type 386 doté de l'environnement Microsoft Windows est en phase de développement

INSCRIPTION

Les inscriptions se prendront sur la base du premier arrivé, premier servi. La date limite pour recevoir les inscriptions sera le 15 août 1990.

Les frais d'inscription sont de 250$ et ils comprennent un repas et la documentation pour l'atelier.

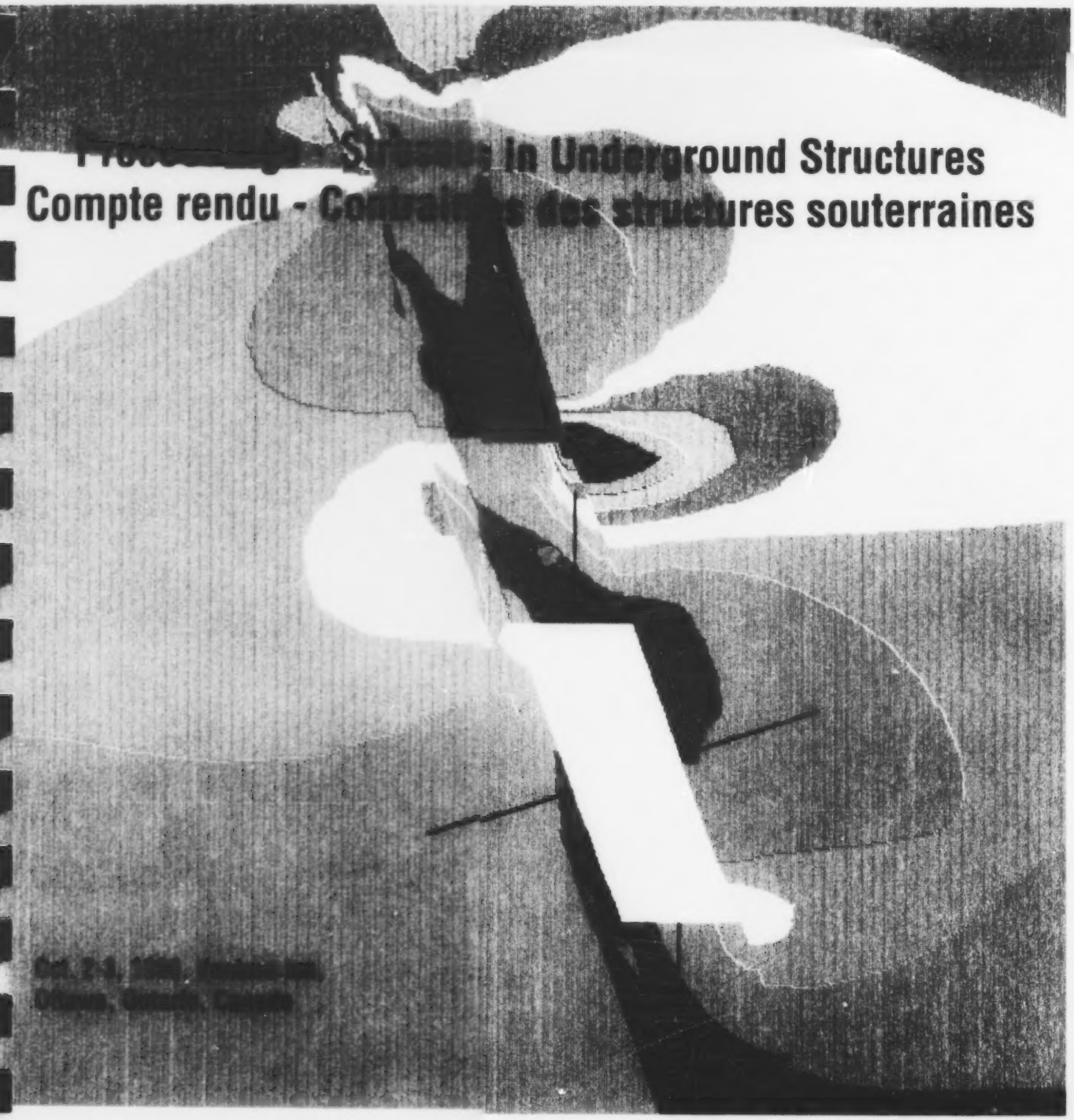
Un remboursement complet sera remis si un avis d'annulation écrit nous parvient avant le 15 septembre 1990.

Faites parvenir vos demandes de renseignements à :
L. Closset
Laboratoire canadien de la technologie minière
LRM/CANMET
555, rue Booth (BCC10)
OTTAWA (Ontario) K1A 0G1
Téléphone : (613) 996-0266
Télécopieur : (613) 995-3456

CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie



Proceedings of Symposium on Ground Support in Underground Structures
Compte rendu - Colloque sur le soutènement des structures souterraines

Oct. 21-23, 1985, Kingston, Ontario, Canada

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES · THE POWER OF OUR IDEAS

L'ÉNERGIE DE NOS RESSOURCES · NOTRE FORCE CRÉATRICE